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FRUIT CROPS--1976: A SUMMARY OF RESEARCH

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CONTENTS

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ON THE COVER: Operating the slotting saw in the orchard. Saw and telescoping boom are mounted on industrial front end loader.

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7-76-3.5M

Influence of Slotting Saw Mechanical Pruning and Alar on Apple Fruit Size and Quality

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INTRODUCTION

Two major problems confronting the Ohio apple industry are increasing costs and dwindling numbers of qualified orchard workers, particularly for pruning operations. Recent studies (6) have shown that pruning is responsible for more than 30% of the cost of growing apples. However, if high quality fruit is to be produced and the trees maintained in a fruitful condition, pruning is an essential annual operation.

In an effort to improve pruning efficiency, various types of cutter bar and circular saw hedging machines have been introduced commercially. These have been used by growers (5) with little experimental evaluation of their effects on tree growth and fruit quality. One major problem which has evolved from plantings topped and hedged with such machines has been a dense periphery of vigorous shoot growth. This growth shades the interior fruiting area of the tree and reduces fruit quality. Often it is recut in successive years, multiplying the number of shoots and increasing the shading effect. This problem is particularly acute when mechanical pruning is not followed by detailed hand pruning and/or nutrition is inadequately controlled.

One alternative to hedge pruning is to use a slotting saw similar to one developed by Cain (1, 3). Instead of cutting branches over the entire surface of the tree, this machine makes a continuous "slot" 24 to 30 inches wide into the side of a row of trees (Fig. 1). The trees are then placed on a 4-5 year cycle, with a new area of the tree cut each successive year. Growth resulting from the cuts is allowed to flower and fruit and receives no further pruning until the cycle is repeated.

METHODS AND MATERIALS

To further study the effects of slot pruning, a slotting saw based on the design of Cain (1) was constructed (4)[2] and a study was initiated to evaluate the effects of different positions and numbers of slot cuts on fruit size and quality. Seventeen-year-old trees of the following six cultivars on M 7 were used

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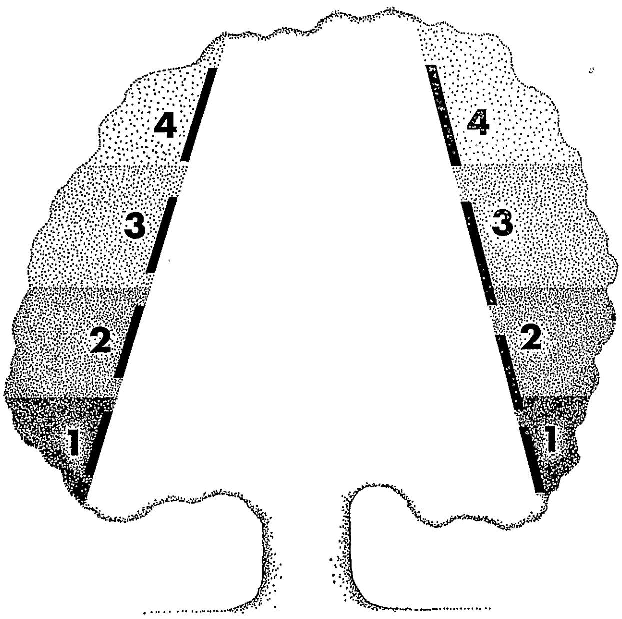
[2]The author expresses appreciation to The Ohio State Horticultural Society for funds for saw construction, to Dr. Ted H. Short for saw design, and to Willard Musselman for field operation of the saw.

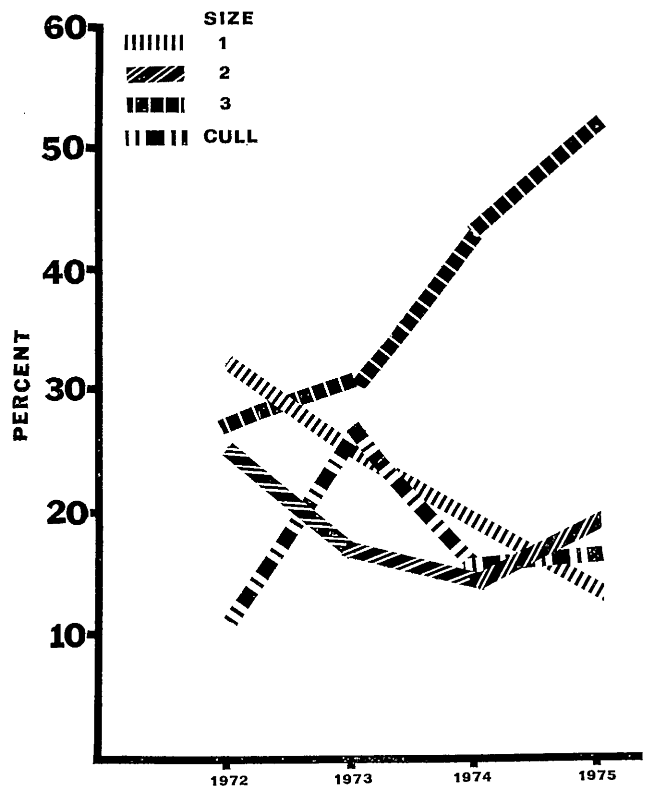
FIG. 1.—Slotting saw and telescoping boom mounted on an industrial front end loader. Extension horizontally is accomplished by adjusting the hydraulic cylinder on top of the boom.



Position of Slotting Cuts

TREATMENT	1972	1973	1974	1975
Check	*Hand*	*Hand*	*Hand*	*Hand*
Bottom	*1*	*2*	*3*	*4*
Middle & Bottom	*1,3*	*2,4*	*None*	*None*
Top	*4*	*3*	*2*	*1*
Bottom+Hand	*1*	*2*	*3+Hand*	*4*

FIG. 2.—Schedule for slotting saw treatments.



FRUIT SIZE HAND PRUNED NO ALAR

FIG. 3.—Fruit size distribution in check treatment.

in this study: Blaxtayman, Gallia Beauty, Golden Delicious, Melrose, Ruby, and Starking Delicious.

The slotting saw treatments shown in Fig. 2 removed 20 percent of the measured tree spread of each cultivar in 1972. The slot cuts were positioned so that at the end of a 4-year cycle the bottom of the tree would have twice the spread of the top. Treatments were made on only two sides of the trees. Lines were laid in the orchard each year to guide the saw operator and insure uniformity. All trees were topped by hand at 15 feet in 1972 and 1974.

A hand gun was used to spray the top half of the tree with Alar (succinic acid 2,2-dimethylhydrazide) at 2000 ppm each year when shoot growth was 4 to 6 inches in length. The treatments were arranged as a split plot with Alar as the main plot and the pruning treatments as the sub-plot with three replications.

The entire yield from each tree was graded each year on an FMC Weight-Sizer and the number of fruit in each of the following size classes was recorded: Size 1—3 1/8 inch diameter and larger; Size 2—2 7/8 to 3 1/16 inch diameter; Size 3—2 5/16 to 2 3/4 inch diameter; Size 4—smaller than 2 1/4 inch diameter. The fruit in Sizes 1-3 were graded on commercial standards and the culled fruit removed and counted. In 1972 prices were secured from a commercial apple marketing association for the various size classes. Sizes 1 and 2 were given tray pack prices, Size 3 bagging price, and Size 4 and culls juice price. The same values were used each year and the dollar values of fruit were calculated.

A 40-fruit random sample of the cull fruit from each tree was evaluated for the primary cullage factor. Shoot growth was determined by measuring five upright shoots in the top of each tree. Chemical thinning materials were used each year and were followed by spot hand thinning in 1973 and 1974. The trees received standard orchard care.

RESULTS AND DISCUSSION

The percentage of Size 1 fruit from the hand pruned trees which received no Alar decreased during the 4 years of this study, while the percentage of smaller Size 3 fruit increased (Fig. 3). The percentage of fruit graded as culls increased dramatically in 1973 due to excessive russet on Melrose and Golden Delicious. The general trend toward smaller fruit on untreated trees must be recognized when the Alar and pruning treatments are being evaluated.

The yearly application of Alar caused a significant decrease in large fruit (Size 1) and a significant increase in small fruit (Size 3) each year of the study (Fig. 4). Alar caused a decrease in the percentage of Size 2 fruit in all years except 1972. Alar caused a significant increase in the number of fruit per tree and an increase in total fruit weight per tree in 1973 and 1974. Although Alar resulted in increases in the total value of fruit produced in 1973 and 1974, in 1975 the overall decrease in fruit size resulted in a 6% drop in the dollar value of Alar-treated fruit. Alar resulted in a 20% to 30% reduction in extension shoot growth in the top of the tree each year of the study.

The slotting saw treatments had different effects on fruit size distribution of various cultivars (Table 1). Since the slotting saw treatments did not begin to affect fruit size distribution until 1974, the 1975 data are most representative of their effects. Gallia Beauty had a higher percentage of fruit in Size 1 and smaller percentages in Sizes 3 and 4 in the hand pruned and combination bottom slot plus hand pruned treatments than in the other treatments. These treatments also resulted in a greater percentage of Size 2 and fewer Size 4 fruit for Starking than the other treatments. No consistent trends in fruit size distribution were evident in the responses of Blaxtayman, Golden Delicious, Melrose, and Ruby to pruning treatments. Pruning treatments had no influence on the dollar value of fruit produced.

All slotting treatments resulted in significantly more fruit per tree on Blaxtayman than hand pruning (Table 1). A tendency also existed for the slotting treatments without hand pruning to increase fruit numbers per tree for Starking. The numbers of fruit per tree of Ruby, Melrose, Golden Delicious, and Gallia Beauty were not influenced by pruning treatments.

Since the influence of the treatments on the primary cullage factors were reasonably consistent throughout the years of the study, only the 1975 data are presented (Table 2). Applications of Alar resulted in fewer fruit being culled for insufficient color and an increase in the percentage of disease and insect culls. Bruising during picking and grading was the most important cullage factor for Blaxtayman and Golden Delicous. Inadequate color resulted in the most culls for Gallia Beauty, Melrose, and Ruby.

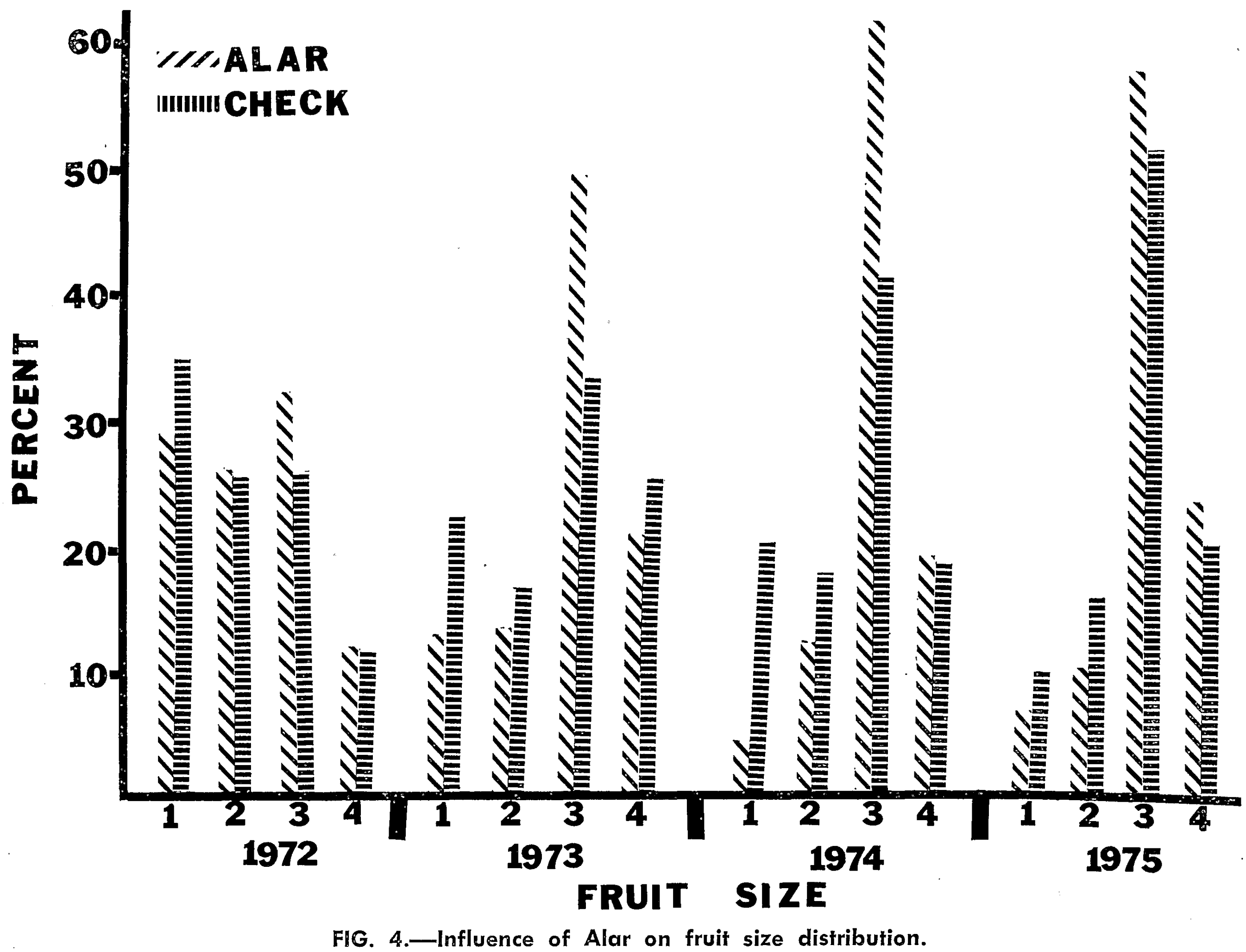


FIG. 4.—Influence of Alar on fruit size distribution.

TABLE 1.—Influence of Slotting Saw Mechanical Pruning on Fruit Size* Distribution and Number of Fruit per Acre of Six Cultivars on M 7 in 1975.

Cultivar	Hand Pruned Check	Bottom Slot	Middle and Bottom Slot	Top Slot	Bottom Slot and Hand	Hand Pruned Check	Bottom Slot	Middle and Bottom Slot	Top Slot	Bottom Slot and Hand
			Percent Size 1					Percent Size 4		
Blaxtayman	0.5	0.4	0.8	0.1	0.1	12.4	24.5	20.2	20.9	16.7
Gallia Beauty	40.8	22.6	28.0	31.6	40.9	0.9	28.3	2.4	18.5	2.0
Golden Delicious	7.7	4.9	7.0	7.8	6.5	12.0	12.2	13.1	12.6	11.7
Melrose	14.4	9.4	6.2	7.5	7.6	1.9	4.5	4.9	2.7	2.1
Ruby	4.1	2.0	1.9	3.8	2.7	11.2	12.3	17.3	12.3	12.1
Starking	2.0	1.5	0.1	0.2	3.9	10.4	28.3	33.2	28.4	18.1
	LSD .05 = 6.1		LSD .01 = 8.0			LSD .05 = 5.7		LSD .01 = 7.5		
			Percent Size 2					Percent Culls		
Blaxtayman	5.1	1.5	4.0	4.2	4.3	4.7	4.4	4.5	4.9	3.8
Gallia Beauty	27.9	25.9	25.6	26.1	22.7	7.5	10.6	8.8	9.0	8.8
Golden Delicious	9.5	9.4	7.8	8.9	8.0	12.8	10.9	11.8	14.1	9.5
Melrose	23.4	21.6	14.2	18.1	20.8	15.9	22.0	25.1	28.9	25.2
Ruby	12.6	10.1	7.9	9.5	12.7	8.2	8.7	11.9	10.5	9.6
Starking	17.8	8.5	3.0	5.3	16.0	4.2	4.7	3.4	3.1	6.7
	LSD .05 = 5.7		LSD .01 = 7.5			LSD .05 = 4.0		LSD .01 = 5.3		
			Percent Size 3					No. of Fruit per Tree		
Blaxtayman	77.3	69.4	70.3	69.0	74.5	2530	3771	3105	3060	3042
Gallia Beauty	22.7	38.0	35.1	31.3	25.6	1736	1729	1605	1811	1460
Golden Delicious	58.1	62.6	60.4	56.6	64.2	2713	2842	2589	2375	2719
Melrose	44.5	42.4	49.7	44.0	44.3	2554	2274	2910	2690	2446
Ruby	63.8	66.9	60.9	63.8	62.9	2310	2339	2457	2019	2266
Starking	65.4	57.0	60.2	62.9	55.3	2665	3101	3528	3216	2296
	LSD .05 = 8.9		LSD .01 = 11.7			LSD .05 = 511		LSD .01 = 672		

*Size 1—3 1/8 inch diameter and larger; Size 2—2 7/8 to 3 1/16 inch diameter; Size 3—2 5/16 to 2 3/4 inch diameter; Size 4—2 1/4 inch and smaller.

TABLE 2.—Primary Fruit Cullage Factors for Trees of Six Cultivars on M 7 Pruned with Mechanical Slotting Saw and Treated with Alar for Four Seasons (1975).

	Primary Cullage Factor (Present)								
	Bruise	Russet	Color	Disease	Insect	Limb Rub	Rot and Crack	Hail	Other
Alar	19.6	11.0	19.0	15.6	6.0	12.9	1.9	2.2	11.3
Check	21.0	8.4	30.0	10.8	4.1	11.1	2.3	1.6	10.5
LSD .05	NS	NS	5.7	3.3	0.96	NS	NS	NS	NS
LSD .01			5.0	4.5	0.31				
Blaxtayman	40.3	28.5	11.6	10.3	8.3	3.4	5.4	10.8	6.9
Gallia Beauty	15.0	7.4	43.0	16.9	8.9	3.4	1.6	0.6	3.0
Golden Delicious	33.7	25.6	1.7	7.2	4.3	17.6	2.2	0.2	7.4
Melrose	11.1	20.8	45.6	2.5	2.9	7.8	0.7	0.2	8.3
Ruby	12.6	0.9	23.5	10.4	2.0	21.4	0.5	0.0	2.8
Starking	9.4	0.7	21.9	31.8	3.9	18.6	2.4	0.0	1.1
LSD .05	7.2	6.6	6.4	5.8	1.7	3.73	1.8	1.6	6.8
LSD .01	9.8	9.0	8.7	7.8	2.3	5.1	2.4	2.1	9.3
Hand (check)	21.0	9.9	20.8	15.6	5.4	12.4	2.5	1.7	10.5
Bottom Slot	21.2	7.2	24.6	13.0	4.1	13.1	2.7	2.0	11.9
Middle and Bottom	18.3	10.8	28.4	13.5	5.4	10.6	2.1	1.6	9.1
Top Slot	19.7	11.4	26.9	11.9	4.1	12.4	1.7	2.3	9.3
Bottom and Hand	21.4	9.2	22.1	11.9	6.1	11.7	1.7	2.1	13.7
LSD .05	NS	NS	5.8	NS	NS	NS	NS	NS	2.9
LSD .01			7.6						3.8

Apple scab disease was the most important cullage factor for Starking.

Pruning treatments had little influence on most of the factors which produced culls. However, in both 1974 and 1975 greater percentages of fruit were culled for inadequate color in the slotting treatments. Slotting plus hand pruning had slightly fewer poorly colored fruit than slotting alone. Poor color on the slotted trees was probably due to excessive watersprout growth in the tree center. Approximately 75% of the culls were in this classification for reasons other than color and in 4 years the slotting treatments had little or no influence on any of these classes.

Slotting required only 6% of the time which hand pruning required. However, when the trees were slotted and not hand pruned for 2 years, 47% more hand pruning time per tree was required in 1974 for an adequate pruning than when hand pruning was done each year. Since slotting alone resulted in decreased fruit size with several cultivars and a general increase in the percentage of poorly colored fruit, some degree of hand pruning would be needed in addition to slotting each year. It is estimated that the amount of hand pruning time required to maintain tree size and improve fruit size and color could be reduced 20-30% by using the slotting saw in conjunction with annual hand pruning.

Many of the trees in this study had multiple leaders or 'umbrella' type scaffold limbs. When these limbs were in the path of a saw, a much larger amount of fruiting wood was removed than was desirable. Experience indicates that the slotting saw should be used as outlined by Cain (2) on central leader trees which have just filled their allotted orchard space. On trees of this type, only smaller limbs (1 inch or less in diameter) would be cut and significant portions of fruiting wood would not be removed at any one time.

Cultivars differed greatly in their adaptability to mechanical pruning with the slotting saw. It is felt that only minor annual hand pruning would be required with cultivars such as Golden Delicious, Blaxtayman, and Ruby. Melrose produced many large watersprouts in the tree center and annual removal of this type growth would be required. Fruit size reduction of Gallia Beauty in the slotted treatments was believed to be due to the lack of detailed thinning out cuts required to maintain good fruit size. There was also a lesser amount of fruiting wood regrowth on stubs of Gallia Beauty left by the saw than with other cultivars.

By far the most difficult cultivar to handle with the slotting saw was Starking. It produced a great number of very vigorous watersprouts all along the main scaffold limbs and down the trunk of the tree. After four growing seasons, many of these watersprouts were 10-12 feet long with very few fruit spurs on them. Fruit size was drastically reduced, with approximately 30% of the fruit smaller than 2 1/4 inch diameter compared to 10% for the hand pruned trees. Apple scab was very severe because of inadequate spray coverage in the centers of these very dense trees. If slotting is to be used with standard habit Delicious, detailed annual pruning must follow the mechanical cuts and slotting must be started before the scaffolds develop an 'umbrella' habit. Straight line cutting removes large amounts of fruiting wood.

Since mature trees and not young trees which had just filled their allotted space were used, it was initially believed that position or cycle of rotation of the cuts would be critical. The position of the cut, top or bottom, had very little effect on the type of regrowth or its flowering or fruiting. The amount of follow-up pruning required to maintain fruit size and quality was of far greater importance.

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Effects of Scoring and Growth Regulators on Flower Initiation, Fruit Set, and Aphid Populations in Young Apple Trees

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INTRODUCTION

Increased production, reduced labor requirements with improved harvest labor efficiency, and promotion of earlier bearing are advantages which have stimulated fruit growers to plant extensive acreages of apples propagated on dwarfing or size-controlling rootstocks. These rootstocks include both the Malling-Merton (MM series) and the earlier introduced Malling (M series). Considerable variation exists in the degree of size control achieved using these rootstocks, especially under conditions of varying soil fertility and soil moisture regimes. Precocity or earliness of bearing and the resultant early return on investment is also influenced. Semi-dwarfing rootstocks such as M 7 or MM 111 often require 5-7 or more years to begin bearing.

Earlier evaluations of rootstock/cultivar responses in research and grower plantings indicated that the MM 106 and M 7 semi-dwarfing rootstocks often induced earlier fruit bud development and significantly greater early fruit yields in comparison to MM 111 (2). Despite some problems with collar rot in heavy, wet soils with MM 106 and potential leaning due to poor root anchorage with M 7, substantial apple acreage has been planted using these rootstocks in Ohio.

While apple cultivars such as 'Golden Delicious' and 'Jonathan' normally bear early, other cultivars, *e.g.*, 'Delicious' and 'Melrose', are typically slow to begin flowering. In addition, the tendency toward poor fruit set often occurs with tardy flowering cultivars on semi-dwarf and semi-standard rootstocks, resulting in low economic returns during early stages of establishment of plantings.

The predominance of 'Red Delicious' strains in commercial orchards and the need for early economic returns in high density plantings has stimulated research on various methods for inducing early flower initiation and promoting increased fruit set. The growth regulators, succinic acid 2,2-dimethylhydrazide (Alar) and (2-chloroethylphosphonic) acid (Ethrel), have been demonstrated in various apple cultivars to induce increased flower initiation when applied 10-14 days after full bloom to young, nonbearing trees (1, 5, 7). Mechanical scoring of trees for promotion of flower buds consists of one or more cuts through the bark and cambium to the sapwood around the trunk or limbs just after bloom and prior to the normal period of fruit bud formation (Fig. 1). Scoring is a centuries-old practice which has produced variable success in inducing fruit bud initiation (1, 4).

Certain growth regulators are also known to increase resistance to attack by insects as previously reported (3). Alar at 2000 ppm reduced the population increase of apple aphid on 'Red Delicious' on standard rootstock. Little is known of the effects of Ethrel and combinations with Alar on aphid populations.

METHODS AND MATERIALS

A study was initiated in May 1974 in a commercial apple orchard to evaluate the influence of scoring and the growth regulators Alar and Ethrel on fruit bud initiation, shoot growth, and aphid populations. A separate test was initiated in the same block May 3, 1974, to examine the influence of these treatments plus a urea application during the bloom period on subsequent fruit set. A severe frost on May 7 eliminated all fruit in this block for the 1974 season. The test was retained, however, for evaluation of the effects of these treatments on return bloom and fruit set in 1975.

Varying rates of Alar, Ethrel, Alar-Ethrel combinations, and scoring were applied on May 24, 1974, 14 days after full bloom, to 4-year old 'Melrose' on M 7 and 'Red Prince', a color sport of 'Delicious' on MM 106 rootstock. Alar rates tested ranged from 500-2000 ppm, Ethrel from 100-1000 ppm, alone and in combinations.

Summer pruning to 2nd and 3rd year wood on 50-60% of the scaffold limb terminals was performed in July 1974. Number of flower clusters, number of fruit, percent fruit set, and shoot growth on five pruned and five unpruned shoots per tree were measured in 1975.

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TABLE 1.—The Effects of Scoring, Alar, Ethrel, and Combined Alar-Ethrel Applications on Flower Initiation in 4-Year-Old Trees of 'Melrose'/M 7 and 'Red Prince'/ MM 106.

	No. of Flower Clusters	
Treatment*	'Melrose'	'Red Prince'
Check	159	9
Scoring	343	111
Alar (2000 ppm)	298	24
Ethrel (600 ppm)	300	34
Ethrel (1000 ppm)	293	79
Alar (1000 ppm) + Ethrel (300 ppm)	347	27
Alar (500 ppm) + Ethrel (600 ppm)	297	63

*Treatments applied 14 days after full bloom.

RESULTS AND DISCUSSION

Although all treatments to enhance flower initiation in 'Melrose' resulted in increased numbers of flowers when compared to untreated trees, only the optimum treatments and responses are shown in Table 1. These treatments also produced the greatest responses in numbers of flower clusters initiated in 'Red Prince'. Scoring and Ethrel at 1000 ppm resulted in averages of 12 and 8.8 times, respectively, the number of flower clusters in check trees of 'Red Prince'.

Scoring, Alar at 1000 and 2000 ppm alone and in combination with Ethrel (Alar 1000 + Ethrel 300 ppm) enhanced the numbers of fruit formed in 'Melrose' (Table 2). Scoring increased the number of fruit formed by 50%, while the other treatments listed more than doubled fruit counts in this cultivar. In comparison with 'Melrose', the numbers of fruit formed in 'Red Prince' were much lower, although all treatments resulted in higher fruit counts in comparison with the check 'Red Prince' trees.

FIG. 1.—Scoring young apple trees to promote flower formation.

Percent fruit set in 'Red Prince' was improved 112% in the year following application in the intermediate Ethrel (600 ppm) treatment (Table 2). Results in other treatments showed a response comparable to that observed in the check tree in this cultivar (Table 2). In 'Melrose', Alar improved fruit set significantly in the year following treatment. Ethrel alone and in combination with Alar reduced fruit set in 'Melrose' in the year following treatment.

Low numbers of fruit formed in 'Red Prince' indicate the negligible effect of scoring in the year prior to bloom on fruit numbers and fruit set the following season. It is important to note that growth regulator treatments to induce flower initiation may have a negligible effect on fruit set the following season. In some instances, *e.g.,* Ethrel may actually reduce fruit set in the season following application.

The problems of delayed flower initiation and poor fruit set in many of the 'Delicious' strains are inherent and distinctly different phenomena. Additional research specifically directed toward improving fruit set is needed.

The dramatic influence of tree scoring on return bloom in 'Melrose' the year following treatment was again apparent in results observed in the study in which scoring and combination scoring/Alar or urea treatments were tested (Table 3). Numbers of fruit formed were also increased in comparison with check trees in this cultivar. An apparent improvement in fruit set in 'Melrose' with the urea application during bloom the year prior to these observations cannot be explained at this time. Although variability between trees was great, the number of flowers formed in 'Red Prince' was improved substantially in all treatments in comparison with the check (Table 3). Scoring + Alar at 2000 ppm resulted in a 12-fold increase in the number of flower clusters formed. Numbers of fruit were low, and were comparable to those observed in 'Red Prince' in the previous test.

The high degree of variability between trees was also apparent in percent fruit set in 'Red Prince' in this test. Fruit set was reduced in scoring, Alar, and urea treatments. Comparisons of these results with those observed in 'Red Prince' in the previous test (Table 2) indicate that reductions in fruit set with scoring and Alar are possible in the year following treatment. Reductions in fruit set in 'Melrose' also occurred in several of the treatments (Tables 2 and 3). It is important to note, however, that percent

TABLE 2.—The Effects of Scoring, Alar, Ethrel, and Combined Alar-Ethrel Applications on Number of Fruit and Percent Fruit Set in 4-Year-Old Trees of 'Melrose'/M 7 and 'Red Prince'/MM 106.

Treatment*	'Melrose' No. of Fruit	'Melrose' Percent Fruit Set	'Red Prince' No. of Fruit	'Red Prince' Percent Fruit Set
Check	70	45	2	24
Scoring	105	33	14	21
Alar (1000 ppm)	151	55	3	15
Alar (2000 ppm)	148	51	7	27
Ethrel (600 ppm)	90	29	13	51
Alar (1000 ppm) + Ethrel (300 ppm)	140	40	5	33
Alar (1000 ppm) + Ethrel (100 ppm)	107	43	6	30

*Treatments applied 14 days after full bloom.

FIG. 2.—Flower initiation on a combination scored/Alar treated tree (left) and on an untreated tree (right) of 'Red Prince' on MM 106 rootstock.

fruit set is based on total numbers of fruit formed. Reduction in fruit set with significant increases in flower initiation and numbers of fruit formed still results in significant increases in potential total yields.

The effects of summer pruning on shoot growth are generally consistent with results obtained in other research programs (Table 4). In making comparisons between treatments, it is important to keep in mind that measurements of shoot growth in summer pruned trees were made on regrowth after pruning. Similar measurements on unpruned shoots were of existing growth for that season. Effects of an increased fruit load in 'Melrose' vs. 'Red Prince' are apparent in the sizeable reductions in shoot growth in comparisons of both pruned and unpruned shoots in these cultivars. Summer pruning appeared to have a negligible effect on reducing shoot growth in 'Red Prince', where low numbers of fruit were produced (Table 2). As expected, maximum reductions in shoot growth were obtained with the higher rates of Alar (2000 ppm) in both cultivars, but were most evident in 'Melrose'.

In comparisons with untreated trees, shoot growth in pruned and unpruned 'Melrose' was reduced by Ethrel applications alone and in combination with Alar at all rates, although growth reduction was generally not as great as that observed with Alar alone (Table 4). Scoring of 'Red Prince' resulted

TABLE 3.—Effects of Scoring, Alar, and Urea on Numbers of Flower Clusters, Numbers of Fruit, and Percent Fruit Set in 4-Year-Old Trees of 'Melrose'/M 7 and 'Red Prince'/MM 106.

	'Melrose'			'Red Prince'		
Treatment	Flower Clusters	No. of Fruit	Percent Fruit Set	Flower Clusters	No. of Fruit	Percent Fruit Set
Check	162	51	43	9	3	55
Scoring	269	100	40	37	11	24
Alar (2000 ppm)	233	87	36	87	11	18
Scoring + Alar (2000 ppm)	367	111	30	110	10	12
Urea (3 lb./100 gal.)	170	91	53	64	8	12
Scoring + Urea (3 lb./100 gal.)	300	86	28	44	8	18
Urea (3 lb./100 gal.) + Alar (2000 ppm)	251	72	28	41	12	36

*Treatments applied 4 days before full bloom.

TABLE 4.—Response in Summer Pruned and Unpruned Shoot Growth in 4-Year Old 'Melrose'/M 7 and 'Red Prince'/MM 106.

	'Melrose'		'Red Prince'	
Treatment	Pruned (cm)	Unpruned (cm)	Pruned (cm)	Unpruned (cm)
Check	41.8	51.5	42.6	43.9
Scoring	31.4	30.2	36.6	33.4
Alar (1000 ppm)	30.1	30.0	34.0	43.3
Alar (2000 ppm)	17.7	20.2	28.3	32.4
Ethrel (600 ppm)	37.3	37.2	49.8	46.5
Alar (1000 ppm) + Ethrel (300 ppm)	24.9	31.8	40.2	41.2
Alar (500 ppm) + Ethrel (600 ppm)	27.4	31.0	36.2	46.1

TABLE 5.—Effects of Scoring, Alar, Ethrel, and Combination Alar/Ethrel Applications on Infestations of Apple Aphids on 4-Year-Old Trees of 'Melrose'/M 7 and 'Red Prince'/MM 106.

Treatment	'Melrose' Average No. Infested Terminals/Tree*	'Red Prince' Average No. Infested Terminals/Tree
Check	69.5	43.6
Scoring	27.9	27.8
Alar (1000 ppm)	33.8	42.5
Alar (2000 ppm)	17.3	37.8
Ethrel (600 ppm)	30.2	90.8
Alar (1000 ppm) + Ethrel (300 ppm)	59.5	29.4
Alar (500 ppm) + Ethrel (600 ppm)	49.0	70.2

*Apple aphid population sample based on observations on 7/30/74 on five to six replicate trees per treatment.

in shoot growth reductions generally comparable to that observed with Alar treatment in either pruned or unpruned trees.

On 'Melrose', the significant reduction in shoot growth induced by Alar at 2000 ppm was paralleled by significantly lower aphid populations per tree (Table 5). On 'Red Prince', the trends are not quite as clear, although the lowest aphid populations were again in the Alar treatments and particularly in the scoring treatments. On both cultivars, combination Ethrel/Alar treatments generally resulted in only a minimal response in reducing aphid populations.

The interacting effects of growth regulators with environment, soil fertility, and management practices in grower orchards continually complicate interpretation of responses observed after application of any single or combination treatments. Results of this test verify the promotive effects of Alar or Ethrel on flower initiation in post-bloom applications. Maximum response with Alar is obtained at higher rates (2000 ppm) and substantiates current recommendations for application to vigorous trees 14-21 days after full bloom. Lower rates (1000-1500 ppm) are suggested for cultivars already bearing a light crop and maintaining moderately vigorous growth.

Ethrel applications at low to moderate rates (300-600 ppm) will promote return bloom comparable to that obtained with Alar applications at 1000-2000 ppm rates. These rates are consistent with current label recommendations for spur-type trees and appear to be adequate for non-spur types such as 'Melrose' in a moderately vigorous condition with a light to moderate crop load. Higher rates (1000 ppm) may be most effective on non-bearing, vigorous, non-spur cultivars such as 'Red Prince' in promoting early flower initiation on a semi-standard rootstock such as MM 106.

The promotive effects of scoring in both cultivars tested suggests that this operation performed on young, non-bearing trees 14-21 days after full bloom can be as effective as the growth regulators Alar or Ethrel in stimulating flower initiation. In high density plantings, scoring of the trunk with one or two cuts generally will require less than 1 minute per tree. Cuts will heal rapidly and generally need not be coated with a protective paint. However, cultivars such as 'Idared' which are highly susceptible to fireblight or other cultivars in orchards with a history of severe fireblight infections should not be scored because of the danger of infection at the suggested time of treatment.

Although the aphid populations were quite variable in this block, as shoot growth is reduced by various treatments, then apple aphid populations are likely to be lower. If these horticultural tools (scoring, Alar, or Ethrel) are utilized by growers for fruit bud initiation and return bloom, additional side benefits can be expected in the form of reduced pressures from apple aphids in young apple plantings.

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Evaluation of New Insecticides and Miticides, 1974-1975

FRANKLIN R. HALL[1]

INTRODUCTION

Many changes in insect control agents have taken place over the past few years. New classes of insecticides and miticides include the synthetic pyrethroids, formamidines, and the tin-based chemicals. New miticides including ZO-856, U-36059, and S-15126 each represent new types of chemistry.

Candidate pesticides must be carefully evaluated for efficacy, phytotoxicity, and selectivity if there are to be appropriate replacements for those orchard compounds under review for possible cancellation. Agricultural chemicals already removed from the market by EPA regulation represent about one-fifth of the major pesticide sales in the U. S. In addition, integrated pest management on apples has resulted in a shift in the choice of chemicals as well as the rates of usage (3). Recent evaluations of new materials on apples have identified compounds with even greater efficiency and selectivity than that of previous compounds (1, 2, 4). This paper reports the results of chemical evaluation experiments on certain apple insects and phytophagous mites.

METHODS AND MATERIALS

Field evaluation experiments were conducted in the Snyder orchard at OARDC during the 1974 and 1975 seasons. Except for the first experiment, apple trees utilized were 10-year-old 'Red Delicious' planted 15 x 35 feet. 'Cortland' apple trees (20-year-old) planted 40 x 40 feet were utilized in the first experiment. All pesticides were applied as dilute sprays with a truck-mounted hydraulic sprayer at 450-500 psi. Estimated volume of spray utilized per acre was 250 gallons for Red Delicious and 400 gallons for the Cortlands. All experiments were conducted with three to six replicate trees per treatment.

Estimates of European red mite, *Panonychus ulmi* (Koch), populations were made by collecting leaves at heights of 4-7 feet around the periphery of each replicate tree. At each sampling date, 25 leaves per tree were picked randomly around the trees and the mites were counted after they were brushed onto glass plates. All counts were made on the day of sampling.

Studies on the control of overwintering eggs of red mite were conducted in the spring of 1975. Five 1 to 2-inch twigs containing 99-155 eggs per treatment were dipped into test solutions on April 25 (ca. 1/2-inch green stage of growth). Treated twigs were allowed to dry and placed upright on tacks surrounded by a ring of Stikem. All twigs were maintained in an insectary during the course of the study.

Branches containing woolly apple aphid, *Eriosoma lanigerum* (Hausmann), were tagged and pre-count estimates were made of the number of separate colonies per terminal (eight per treatment). Post-spray counts were made by counting the total number of aphids alive 8 days after treatment. All plots were sprayed to drip with a 1-gallon hand sprayer on July 15, 1974.

Laboratory

Plum curculios, *Conotrachelus nenuphar* (Herbst), were reared by collecting infested plums and placing emerged larvae into pots containing soil. Adults were collected as they emerged in August 1975. Four Rome apples were dipped into test solutions, allowed to dry, and placed in a screened box (two boxes per treatment). Ten adult curculios were placed in each box, water was provided, and all data were recorded at 3 days after treatment. Laboratory temperatures were maintained at 72 ± 2° F. and RH = 55%. At 3 days from treatment, the number of adults unable to walk were recorded as dead and counts were made of the number of feeding scars on each apple.

RESULTS AND DISCUSSION

Field Study

In 1974, several new compounds showed excellent activity against European red mite (Table 1). Vendex, a new tin miticide recently registered for use on apples, shows good efficacy against red mite. Although it is not as fast as Plictran on knockdown of adult mites, it does have good residual activity. Both Plictran and Vendex are recommended for control of

TABLE 1.—Control of European Red Mite (Panonychus ulmi **(Koch)) on Apples with Miticides in 1974.**

Material	Rate Formulation/ 100 Gal.*	Av. No. Mites/Leaf and Sampling Dates		
		Pre-spray 7/8	7/16	7/24
Plictran 50 WP	4 oz.	16.83	0.60	0.0
U-36059 1.66 EC	16 fl. oz.	20.73	2.42	0.19
Vendex 50 WP	4 oz.	4.06	1.36	0.07
Vendex 50 WP	2 oz.	5.50	1.36	0.15
U-42564 6 EC	6 fl. oz.	7.77	1.01	0.06
Unsprayed Check		4.60	5.20	3.86

*All plots treated July 9, 1974.

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phytophagous mites in integrated control programs because of their safety to the primary predator, *Amblyceius fallacis* (Garner).

Tables 2 and 3 show the efficacy of S-15126 (malonoben) and U-36059 (BAAM), both compounds of new structure. The use of Cygon as late as July resulted in a typical suppression and subsequent explosion of mite populations 1 month later. Its use is recommended only early in the season when predator activity is much lower and when aphids are the prime target. Production of Acaralate has been discontinued by the company and the further development of AC-85258 on apples has been terminated by its manufacturer.

For control of overwintering red mites, ZO-856 (Zardex) has shown activity very comparable to that of superior oil (Table 4). Zardex is primarily an ovicide and has a temporary permit for experimental use in grower orchards in 1976. BAAM is a new product (new chemistry) effective on all stages of mites and has especially good activity against organophosphate-resistant pear psylla, *Psylla pyricola* Foerster, with a temporary permit in 1976 for use against these pests.

Imidan, followed by Zolone and Guthion, showed excellent activity against woolly apple aphid, which can be difficult to control once a population gets established in an orchard. Sevin was only marginally successful and Vydate counts were not significantly different from the check (Table 5).

Laboratory Studies

The evaluation of various materials for efficacy against plum curculio showed that there are some exciting new compounds available for the control of a very difficult insect pest. Guthion is still the standard insecticide, but FMC 33297 and Shell 43775

TABLE 2.—Control of European Red Mite (Panonychus ulmi **(Koch)) on Apples with Miticides in 1974.**

Material	Rate Formulation/ 100 Gal.*	Av. No. Mites/Leaf and Sampling Dates: Pre-spray 7/18	7/31	8/14
S-15126 50 WP +	6 oz.	18.25	0.08	0.00
B-1956	4 oz.			
Plictran 50 WP	4 oz.	12.89	0.03	0.09
Galecron 4 EC	1 pt.	11.12	0.16	0.04
Acaralate 2 EC	2 pt.	12.15	1.52	0.43
Galecron 4 EC +	1/2 pt.	8.66	0.29	0.37
Acaralate 2 E	1 pt.			
Unsprayed Check		4.45	3.97	2.52

*All plots treated July 19, 1974.

TABLE 3.—Control of European Red Mite (Panonychus ulmi **Koch)) on Apples with Miticides in 1975.**

Material	Rate Formulation/ 100 Gal.*	Av. No. Mites/Leaf and Sampling Dates: Pre-spray 7/2	7/9	7/21	8/4
U-36059 1.66 EC	3/4 pt.	5.25	0.03	0.01	0
U-36059 1.66 EC	1 1/2 pt.	3.95	0.07	0.15	0.04
AC-85258 25 WP	1 lb.	5.04	0.12	0.97	0.91
Cygon 267 EC	1 pt.	13.13	0.35	6.60	37.15
Cyprex Check	1/2 lb.	0.43	1.17	1.23	3.43
Unsprayed Check		4.87	3.85	0.87	0.48

*All plots treated July 3, 1975. Cyprex 65 WP included in plots 1-5.

TABLE 4.—Control of Overwintering Eggs of European Red Mite (Panonychus ulmi **(Koch)) on Apples in 1975.**

Material	Rate Formulation/ 100 Gal.	Percent Hatch*
ZO-856 40 WP (Zardex)	1 lb.	5.4 c
Sun 7E Superior Oil	1%	0.0 c
U-36059 1.66 EC	3.4 pt.	59.4 b
Water Check		96.8 a

*Means followed by the same letter are not significantly different at the 5% level.

TABLE 5.—Control of Woolly Apple Aphid (Eriosoma lanigerum **(Hausmann)) on Apples in 1974.**

Material	Rate Formulation/ 100 Gal.	Av. No. Colonies/Terminal Pre-spray 7/15	Av. No. Live Aphids per Terminal 7/23*
Pirimor 50 WP	2 oz.	5.0	2.9 c
Pirimor 50 WP	4 oz.	4.0	1.3 c
Zolone 3 EC	0.5 pt.	3.8	0.5 c
Imidan 70 WP	1.0 lb.	2.9	0.0 c
Guthion 50 WP	0.5 lb.	4.6	0.6 c
Sevin 50 WP	1.5 lb.	4.3	5.9 b
Vydate L	0.4 pt.	3.8	12.3 a
Water Check		3.5	17.4 a

*Means followed by same letter are not significantly different at 5% level.

TABLE 6.—Screening Experimental Insecticides in the Laboratory for Control of Plum Curculio (Conotrachelus nenuphar **(Herbst)) in 1975.**

Material	Rate Formulation/ 100 Gal.	Percent Mortality at 3 Days Exposure	Average No. Feeding Scars/Apple at 3 Days*
Mobil 9087 2 EC	2 qt.	0	5.4 b
Carzol SP	0.25 lb.	0	8.3 a
Imidan 70 WP	0.75 lb.	100.0	1.5 c
FMC-33297 25 WP	0.01 lb.	6.3	0.3 c
FMC-33297 25 WP	0.02 lb.	85.0	0.1 c
Water Check		0	8.1 a

*Means in the same column followed by the same letter are not significantly different at the 5% level.

(synthetic pyrethroids) both show promise for control of plum curculio (Tables 6 and 7). Both compounds exhibit knockdown at low rates (0.25 to 0.05 lb. a.i./ 100 gal.) and in addition prevent feeding damage from the adult curculio. If these materials demonstrate residual activity in the field, then together with the 100-fold increase in mammalian safety (Dermal) over that of parathion, they should be very useful compounds in fruit insect programs.

Additional information on specificity and selectivity of these new compounds against orchard pests is needed if they are to be utilized to best advantage in the minimum-use pesticide programs of the future.

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TABLE 7.—Screening Experimental Insecticides in the Laboratory for Control of Plum Curculio (*Conotrachelus nenuphar* **(Herbst)) in 1975.**

Material	Rate Formulation/ 100 Gal.	Percent Mortality at 3 Days Exposure	Average No. Feeding Scars/Apple at 3 Days*
	Test No. 1		
Guthion 50 WP	0.5 lb.	100	1.0 b
Guthion 50 WP	0.25 lb.	100	0.8 b
Guthion 50 WP +	0.25 lb.	95	0.4 b
Lannate 2 L	1 pt.		
Lannate 2 L	2 pt.	0	5.3 a
FMC-33297 25 WP	0.015 lb.	25	0.0 b
FMC-33297 25 WP	0.02 lb.	100	0.1 b
Sevin 50 WP	2 lb.	85	2.9 b
Water Check		0	4.5 a
	Test No. 2		
PP-557 25 EC	1 qt.	5	2.1 b
Shell 43775 2.4 lb. EC	78 ml.	95	0.3 c
Shell 43775 2.4 lb. EC	156 ml.	100	0 c
Shell 43775 2.4 lb. EC	312 ml.	100	0 c
Guthion 50 WP	0.5 lb.	100	0.4 c
Water Check		0	6.3 a

*Means in the same column followed by the same letter are not significantly different at the 5% level.

Low-volume Spraying and Pest Control on Apples

F. R. HALL and D. C. FERREE[1]

INTRODUCTION

The advantages of low-volume spraying are enhanced with the continued trend to smaller apple trees throughout Ohio. Many new types of application equipment are being offered to growers which can impose new problems of calibration and adequate spray coverage (1). Previous studies have shown excellent control of both insects and disease with the use of low-volume machinery in comparison to standard air-blast sprayers (3, 4, 5). This paper reports the results of a 2-year study on three different sprayers and their use in high-density apple orchards.

MATERIALS AND METHODS

1974

In 1974 a 3P-50 Pony Kinkelder PTO sprayer (Fig. 1) was utilized in a high-density apple orchard planted 12 x 20 feet in 1968. Six cultivars on M 26 rootstock (Golden Delicious, Red Prince, Gallia Beauty, Blaxtayman, Jonathan, and Melrose) were planted (nine trees per row) in six blocks with 24 feet between blocks. The trees were maintained at a height of 10 feet. The PTO sprayer was calibrated to deliver 20 gallons per acre (GPA), 10 GPA, and 10 GPA plus spreader-sticker in season-long schedules. The amount of spray material used per acre was 20% less than the recommended dosage per 100 gal. label rate as per the current Ohio low-volume spray recommendations. The same amount of pesticide was used per acre irrespective of the spray volume.

Insect and disease injury to the fruit was measured by passing all the fruit from each tree over a weight-sizer and counting the number of damaged fruits. Mite and aphid counts taken during the season showed no significant differences between the treatments and are not reported here.

1975

In 1975, two air-blast sprayers were utilized throughout the season in a block of semi-dwarf trees on M 7 rootstocks. Six cultivars (Golden Delicious, Red Delicious, Gallia Beauty, Blaxtayman, Ruby, and Melrose) were planted in 1955 at a spacing of 30 x 35 feet and ranged from 15 to 17 feet in height. A Myers 2A36 sprayer (Fig. 2) was calibrated to deliver 100 GPA and an experimental Myers 803S PTO sprayer (Fig. 3) was calibrated to deliver 36 GPA. The amount of spray material used per acre was reduced 20% as in 1974. Approximately 90 trees (total) of the six cultivars were covered by each treatment (sprayer).

As in 1974, fruit from each tree were passed over a grader at harvest. A 40-fruit sample of each cultivar (six replications) was taken from the culls of each size class and the amount of insect and disease injury determined. Pest observations included damage from plum curculio, *Conotrachelus nenuphar* (Herbst); codling moth, *Laspeyresia pomonella* (L); redbanded leafroller, *Argyrotaenia velutinana* (Walker); and apple scab, *Venturia inaequalis* (Cke.) Wint. Counts were also taken of European red mite, *Panonychus ulmi* (Koch), by sampling 25 leaves per tree, with a minimum of four replicates.

The trees in the dwarf orchard (M 26) were utilized for an additional experiment with the 3P-50 Pony Kinkelder sprayer. Three randomized blocks with 18 trees of each variety were treated with: 1) the sprayer calibrated to deliver 20 GPA at the normal recommended rates, and 2) the sprayer calibrated to deliver 20 GPA at one-fourth the normal rates (insecticides and fungicides). Fruits were graded at harvest as in 1974 and the amount of insect and disease injury recorded.

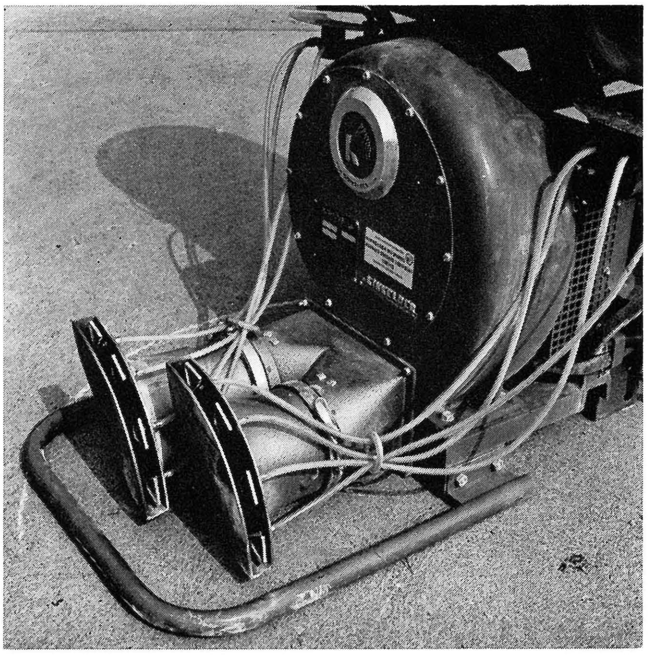

FIG. 1.—3P-50 Pony Kinkelder PTO sprayer used in high density orchard in 1974.

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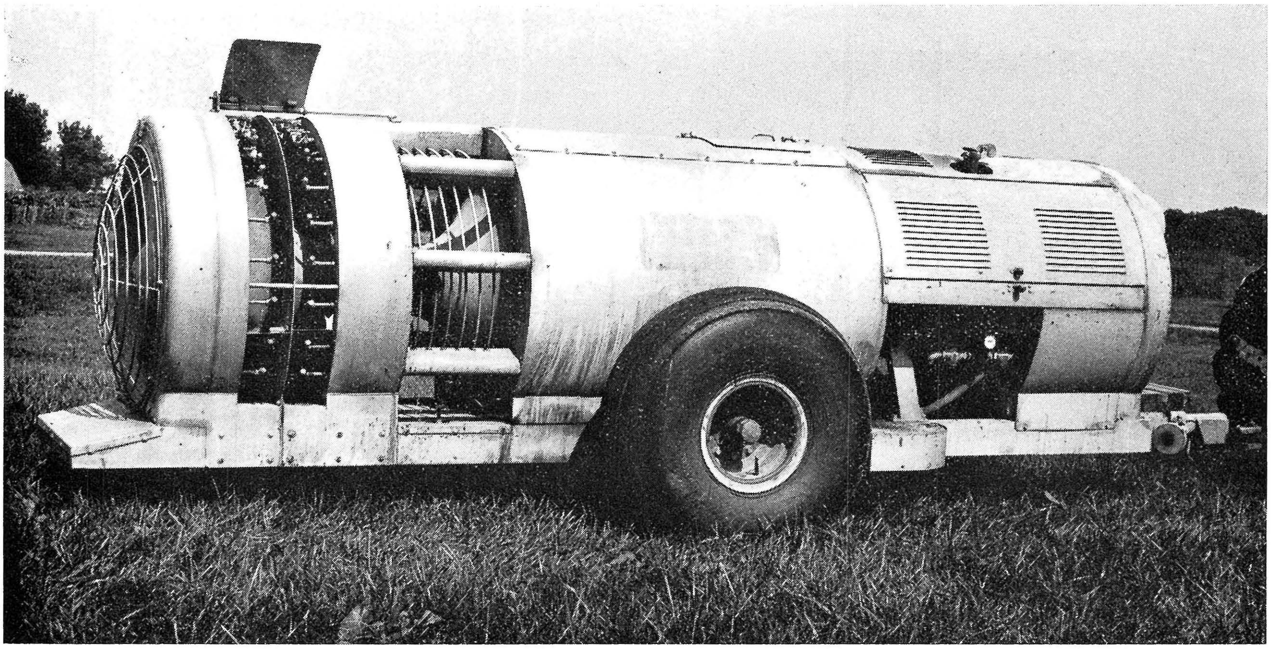

FIG. 2.—2A36 sprayer used in semi-dwarf orchard in 1975.

RESULTS AND DISCUSSION

1974

In the dwarf apple orchard (M 26) in 1974, very little damage from either insects or disease was recorded. Table 1 gives the results from three varieties of fruit analyzed at harvest. No significant differences were obtained between 20 GPA and 10 GPA with or without the spreader-sticker. Varietal differences were minimal. These results compare favorably with previous studies of Hall *et al.* (5), who reported good control of major apple problems with low gallonage spray equipment.

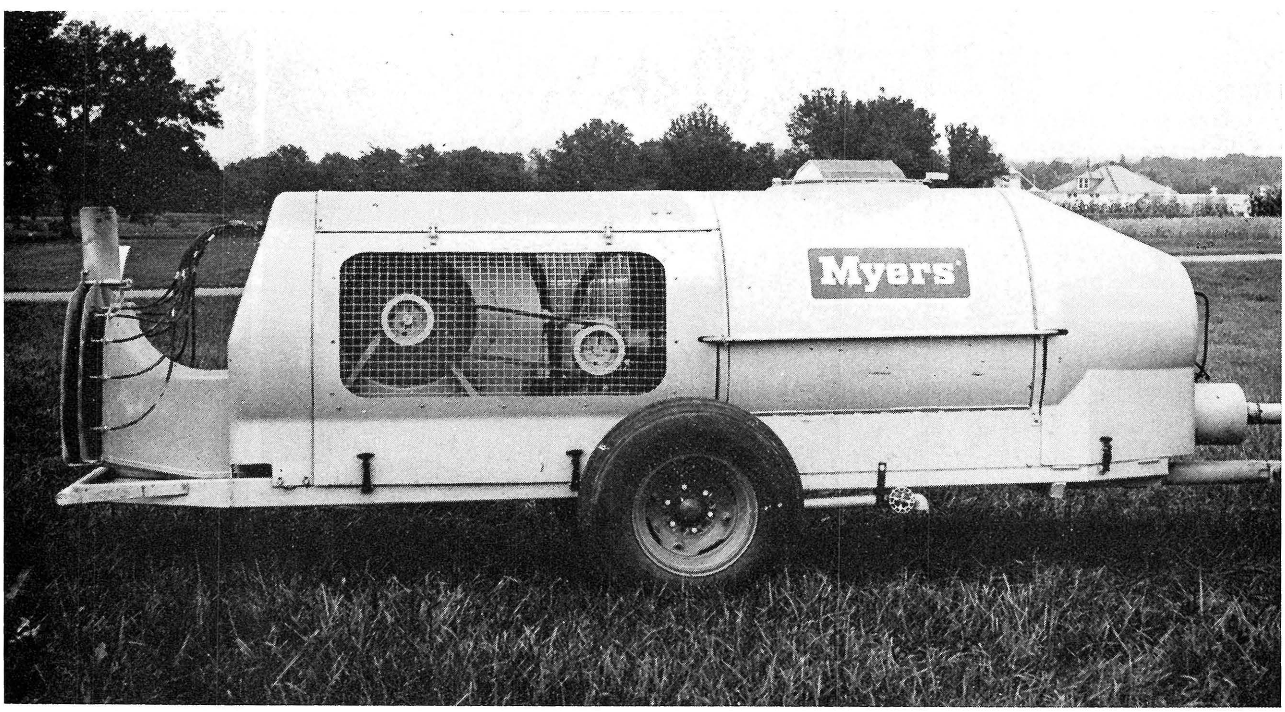

FIG. 3.—Experimental 803S PTO sprayer used in semi-dwarf orchard in 1975.

TABLE 1.—Effects of Spray Volume on Insect and Disease Injury in a Dwarf (M 26) Apple Orchard, 1974.

Treatment	Variety	Percent Fruit Damage at Harvest: Plum Curculio	Codling Moth	Redbanded Leafroller	Apple Scab	Other
20 GPA						
	Jonathan	0.1	0	0	0	0.2
	Red Delicious	0.3	0	0	0.1	0.2
	Blaxtayman	0.1	0	0	0	0.6
10 GPA						
	Jonathan	0.4	0	0	0.1	0.3
	Red Delicious	0.1	0	0	0.1	0.5
	Blaxtayman	0.2	0	0	0.1	0.5
10 GPA + Spreader-Sticker*						
	Jonathan	0.2	0	0	0.1	0.4
	Red Delicious	0.3	0	0	0	0.1
	Blaxtayman	0.1	0	0.1	0	0.4

*Biofilm added at 2 oz./acre.

1975

In the M 7 orchard, mite and apple scab counts on foliage did not reveal significant differences between treatments (Table 2). Red Delicious had higher mite counts and Golden Delicious had the highest foliar apple scab counts. There was only a minimal difference in mite populations between upper and lower sections of the sampled trees.

An analysis of culls at harvest showed little difference in insect control at harvest between the 100 GPA treatment vs. the 36 GPA treatment (Table 3). Apple scab infection of fruit was high at harvest on all varieties, and especially on Red Delicious and Gallia Beauty on the 100 GPA treatment. Apple scab infections of fruit in the 36 GPA treatment were much higher on all varieties and more than doubled that on the 100 GPA treatment (Table 3). Although the

TABLE 2.—European Red Mite and Apple Scab Infestation on 100 GPA and 36 GPA Treatments, 1975.

Variety	Av. No. European Red Mites per Leaf* 6/23	7/7	Percent Terminal Leaf Infection by Apple Scab 7/21-22† Upper	Lower
	100 GPA			
Red Delicious	0.1	2.5	3.8	5.0
Blaxtayman	0.3	0.4	4.2	4.7
Golden Delicious	0.1	0.4	2.7	7.3
	36 GPA			
Red Delicious	0.4	1.6	5.7	1.1
Blaxtayman	0.1	1.3	4.5	4.9
Golden Delicious	0.1	0.4	2.3	6.1

*Counts based on 25 leaves per tree, four trees per treatment at each sampling date.

†Five terminals from upper and lower parts of four trees per variety sampled and number of infected leaves per terminal recorded.

TABLE 3.—Pest Control Comparison of Standard Airblast Sprayer at 100 GPA and Experimental PTO Sprayer at 36 GPA in Semi-dwarf Apple Trees, 1975.

Variety	Percent Culls/ Tree	Analysis of Culls at Harvest* Percent Fruit Damage: Plum Curculio	Codling Moth	Redbanded Leafroller	Other Insects	Apple Scab
	100 GPA					
Gallia Beauty	9.3	0	0	0.2	7.7	12.2
Blaxtayman	4.1	0	0	0	3.4	3.4
Melrose	18.2	0.5	0	0.2	2.7	2.9
Red Delicious	4.6	0	0	0	3.5	20.4
Golden Delicious	10.1	0	0	0	3.8	2.9
Ruby	10.0	0	0	0.2	2.2	6.3
Overall Mean		0.1	0	0.2	3.4	8.1
	36 GPA					
Gallia Beauty	8.7	0	0	0	5.5	26.8
Blaxtayman	5.1	0	0	0	3.9	16.9
Melrose	27.6	0.2	0	0	3.1	4.2
Red Delicious	4.0	0.3	0	0	4.4	43.2
Golden Delicious	13.7	0.4	0	0	5.3	10.9
Ruby	9.7	0	0	0	3.3	15.3
Overall Mean		0.2	0	0	4.3	19.6

*Ratings based on 40 fruit samples from culls at harvest ranging from 360-639 per variety.

TABLE 4.—Effects of Pruning on Control of European Red Mite by Two Sprayers, 1975.

		Av. No. Mites/Leaf 7/15*			
		Inside Tree†		Outside Tree†	
Pruning Treatment	Variety	100 GPA	36 GPA	100 GPA	36 GPA
Hand Pruned	Red Delicious	32.4	29.6	1.6	8.0
	Golden Delicious	3.2	1.8	0.3	1.1
	Rome	0.8	0.5	0.3	0.4
Slotting Saw	Red Delicious	58.6	77.9	15.4	4.9
	Golden Delicious	1.5	2.6	1.1	3.5
	Rome	4.6	1.5	0.9	1.1

*Counts based on 25 leaves per tree, two trees per variety at each sampling location.
†Inside tree, leaf samples from 6 feet around trunk; outside samples from leaves on outside periphery of tree.

amount of scab on culls ranged as high as 43% on Red Delicious in the 36 GPA treatment, the total cullage for this treatment was only 4.0%. Analysis of all factors from both treatments showed the major factors for cullage were poor color and bruises, also noted in a previous study (2).

The extent of pruning on apple trees was expected to influence spray coverage by sprayers. Table 4 gives the results of mite counts on trees which were hand-pruned vs. mechanically pruned trees. Trees pruned with the slotting saw had excessive water-sprout growth in the tree centers and were generally denser than the hand pruned trees. Red Delicious had high mite populations in the tree centers under both sprayer treatments. Populations were significantly higher where the slotting saw was utilized for pruning. Red mite populations were generally lower on the periphery of the trees and, with one exception, were lower on the 100 GPA treatment. Dense foliage can also result in inadequate spray coverage which may lead to higher insect pest populations such as aphids or various leafrollers, as well as apple scab (noted in Table 3). In addition, a general increase

TABLE 5.—Effects of Reduced Pesticide Rates on Amount of Fruit Classed as Culls in the M 26 Orchard, 1975.

	Percent Culls at Harvest*	
Variety	Normal Rate	Reduced Rate†
Melrose	26.2	34.6
Stayman	12.2	26.6
Red Delicious	12.5	28.5
Golden Delicious	16.4	26.5
Gallia Beauty	16.7	34.2
Jonathan	7.4	8.9

*Percentage of fruit per tree graded as culls.
†Rates of all pesticides reduced to one-fourth of standard recommendations.

TABLE 6.—Major Insect and Disease Cull Factors from Reduced vs. Normal Rates of Pesticides on Dwarf Apples (M 26), 1975.

	Percent Fruit Damage at Harvest*					
Variety	Plum Curculio	Codling Moth	Redbanded Leafroller	Other Insects	Apple Scab	Other Factors†
		Normal Rate				
Gallia Beauty	0.2	0	0	4.2	50.8	44.8
Blaxtayman	0.0	0	0	4.8	39.2	56.0
Melrose	0.6	0	0	2.9	17.5	78.9
Red Delicious	0.2	0	0	2.5	65.6	31.7
Golden Delicious	0.0	0	0	3.7	7.1	89.2
Jonathan	0.8	0	0	6.2	3.4	89.6
Average of All Varieties	0.3	0	0	4.1	30.6	65.1
		Reduced Rate				
Gallia Beauty	0.2	0	0.4	4.8	78.8	15.9
Blaxtayman	0	0	0.0	3.1	54.3	42.6
Melrose	0	0	0.0	2.9	48.6	48.4
Red Delicious	0	0	0.0	0.9	89.9	9.2
Golden Delicious	0.4	0	0.0	2.4	36.5	60.8
Jonathan	0.9	0	0.6	5.9	13.3	79.3
Average of All Varieties	0.3	0	0.2	3.4	53.6	42.7

*Ratings based on 20 samples from culls of each tree per variety per treatment.
†Other factors include poor color, bruises, mechanical damage, and other diseases.

in the percentage of poorly colored fruit may also be anticipated if pruning is inadequate (2).

In the M 26 orchard, the effect of the one-fourth strength pesticide application at 20 GPA was very obvious during the season (Table 5). An approximately 3-inch rainfall was recorded just after bloom and no adjustments were made in the sequence of sprays. Table 5 shows that the amount of culls was about double on the reduced rate treatments. The analysis of the insect and disease cull factors responsible for this amount of damage is shown in Table 6. While the reduced rate had little effect on insect damage in the first year of reduced rates, it had a significant effect on the amount of damage from apple scab in all varieties. Red Delicious received the most damage from apple scab on the reduced treatment, while Jonathan was the least susceptible to apple scab.

Secondary infections of apple scab became obvious by lesions on foliage in the reduced pesticide block by mid-June. A special spray of benomyl (6 oz./100 gallons) was applied on June 18 with the low volume sprayer (20 GPA) and compared to a dilute application of benomyl (same rate per acre) by the Myers 2A36 (350 GPA) in a nearby M 9 orchard. After one spray, the dilute application had reduced the percentage of spore germination from 49% (check) to 3% vs. 17% in the low-volume application trees. A second low-volume application in the reduced pesticide block 1 week later further reduced the germination of apple scab to 3.5%.

Red mite populations were also monitored during the season and, as the data in Table 7 indicate, there was a gradual buildup of mites in the reduced pesticide block in mid-July. Following the use of Plictran at 1.8 lb./acre (ca. one-half standard rates) in both blocks in one application on July 16, the population declined rapidly and was not a problem during the rest of the season.

CONCLUSIONS

Low-volume applications of pesticides will control insects and diseases of apples if applied correctly. Timing and rate are especially important in the case of apple scab. When trees are mechanically pruned and are not followed with hand pruning, control of certain pests such as mites and apple scab may also be expected to be more difficult, especially where low volume units are used. Decreased ground speed (2-2.5 mph) of low-volume sprayers is needed for adequate penetration into such trees. The degree of difficulty in control of certain fruit pests will vary considerably from year to year because of environmental conditions (weather).

TABLE 7.—Effects of Reduced Pesticide Rates on European Red Mite Populations in the M 26 Orchard, 1975.

Variety	Av. No. Mites/Leaf and Sampling Date			
	6/18	7/7	7/23	8/6
Normal Rate				
Golden Delicious	0.2	0.1	0.0	0.0
Red Delicious	0.9	0.1	0.1	0.1
Melrose	0.2	0.3	0.1	0.1
Reduced Rate				
Golden Delicious	0.2	2.7	0.1	0.0
Red Delicious	1.1	6.9	0.1	0.0
Melrose	1.1	9.2	0.1	0.0

ACKNOWLEDGMENTS

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Apple Disease and Insect Control by Pesticide Injection

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INTRODUCTION

Commercial production of tree fruits is impossible at the present time without extensive use of pesticides. Prior to development of airblast sprayers, apple pesticides were applied in approximately 400 gallons of water per acre. Currently, the same quantity of pesticide, or even less, is applied in 130 to 40 or less gallons of water per acre. Airblast sprayers, however, tend to overspray the lower portions of a tree before adequate deposition occurs in the center and top (3, 5). It is estimated that up to 30% to 45% of the pesticide applied by airblast sprayers is not deposited on the tree (12). In addition to the problems of drift and environmental contamination, foliar spray deposits are subject to removal by rainfall as well as degradation by temperature, light, and moisture, and sprays must be repeated several times during the growing season.

Recently, tree injection techniques using the systemic fungicides benomyl (11) and methyl-2-benzimidazole carbamate (2, 4, 13) have been successful for control of Dutch elm disease and chestnut blight. Remission of pear decline (6) and peach X disease (6, 8, 9) symptoms, caused by mycoplasma-like organisms, and of peach bacterial spot (9) has been achieved by low pressure injection of tetracyclines. Translocation and distribution of benzimidazole fungicides injected into apple (7) and pear (10) trees were studied, but disease control was not evaluated and little is known of insect control with these techniques.

Use of disease and insect control techniques incorporating tree injection of systemic fungicides and insecticides would virtually eliminate environmental contamination caused by chemical drift and runoff. In addition, a single treatment may be effective throughout an entire growing season. This paper reports the results of preliminary investigations of the use of injection techniques in apple trees for disease and insect control.

MATERIALS AND METHODS

Research was initiated at OARDC in 1975 to determine the effects of injections of experimental, systemic fungicides and insecticides on fruit diseases and insects. Injections were made into randomized single limbs 10 cm (4.0 inches) average diameter on mature 'Cortland' apple trees through two opposite injection holes drilled 1.3 cm (0.5 inch) diameter, 6.4 cm (2.5 inch) depth, and 1.25 to 1.85 meters (4 to 6 feet) from the main trunk. One-half liter of aqueous solution containing 2.5 grams active ingredient (a. i.) was injected per limb, using 50 to 80 psi. The first injection was on April 16, and a second set of limbs, sprayed with captafol (Difolatan) on April 9, was injected on June 13, 1975. Fungicides were combined with either dimethoate (Cygon) or oxamyl (Vydate). Each fungicide-insecticide combination was replicated three times.

Leaf scab [caused by *Venturia inaequalis* (Cke.) Wint.] and powdery mildew [caused by *Podosphaera leucotricha* (E. & E.) Salm.] counts were made on six terminals per limb on July 8 and June 5, respectively, and fruit scab counts on 25 fruits per limb on Sept. 3. Fruit samples for residue analysis were taken at harvest on Oct. 9.

RESULTS

Fruit on trees injected with EL 222-Vydate had significantly less scab than non-injected controls (Table 1). This may be a result of decreased leaf infection. Fruit residue analyses are not yet complete. Leaf scab was significantly less on trees injected with EL 222-Vydate, DPX 10-Vydate, acid, and water than on non-injected trees (Table 1). Additional testing is necessary to establish the validity of these data, and to determine if commercially ac-

TABLE 1.—Effects of Several Systemic Fungicides and Insecticides, Applied by Injection, on Apple Scab and Powdery Mildew, 1975.

Treatment*	Percent Fruit Scab†	Percent Leaf Scab†	Percent Powdery Mildew†
EL 222-Vydate	21 a	11 a	67 abc
XE 326-Vydate	50 ab	28 ab	65 ab
DPX 10-Vydate	57 ab	6 a	68 abc
DPX 10-Cygon	65 ab	19 ab	75 c
XE 326-Cygon	67 ab	25 ab	72 bc
EL 222-Cygon	92 b	39 b	60 a
Water	49 ab	8 a	65 ab
HCL	55 ab	6 a	66 ab
N.I.‡	85 b	42 b	70 bc

*Trees injected on April 16, 2.5 grams a.i./tree in 0.5 liters, 50 to 80 psi.

†Figures represent the means of three replications. Numbers followed by the same letter within columns are not significantly different at p=0.05 according to Duncan's Multiple Range Test.

‡Non-injected control.

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TABLE 2.—Effects of Several Systemic Fungicides and Insecticides Applied by Injection on Rosy Apple Aphid, 1975.

	Average No. Infested Clusters/2 Minute Search*					
Treatment†	Vydata	Check	Percent Reduction	Cygon	Check	Percent Reduction
TBZ 20%	4.3	13.0	66.9	3.7	11.7	68.4
EL 222	5.0	17.0	70.6	6.0	15.0	60.0
XE 326	1.7	14.0	87.9	3.7	6.5	43.1
TBZ 42%	2.0	13.0	84.6	2.0	10.0	80.0
DPX 10	1.3	9.0	85.6	7.0	10.0	30.0
Triforine	0	13.7	100.0	1.5	8.0	81.2

*Counts made on April 29 on all injected branches plus an equivalent number of check branches on the same tree.
†Trees injected on April 16, 2.5 grams a.i./tree in 0.5 liters, 50 to 80 psi.

ceptable control can be obtained. None of the chemicals in this study effectively controlled apple powdery mildew (Table 1). Phytotoxicity observed in this study was primarily attributed to Vydate, although no phytotoxicity was observed with the EL 222-Vydate combination. Scab infection on trees sprayed with captafol was extremely light, so no determination of injection efficacy could be made.

In addition to the fungicides listed in Table 1, triforine (6.5% EC), thiabendazole (20% LC), and thiabendazole (42% F) were tested in this study. They were found unsuitable for further study due to poor uptake, phytotoxicity, or lack of activity against scab and powdery mildew.

Severe powdery mildew infection invalidated counts of European red mite, *Panonychus ulmi* (Koch). Table 2 gives data on the control of rosy apple aphid, *Dysaphis plantaginea* (Passerini). With the exception of DPX 10 and XE 326 combinations with Cygon, all treatments resulted in significant reductions in the number of blossom clusters infested with rosy aphid.

DISCUSSION

Using the injection technique described here, a tree could be treated in 5 minutes. One fungicide (EL 222) appeared to control leaf and fruit scab. It must be emphasized that these trees were treated only once during the 1975 season. The EL 222-Vydate treatment was not phytotoxic.

Injection research is being continued in 1976. Techniques for rapid injection of small quantities of concentrated pesticides will be studied. Several rates of EL 222 will be tested, both alone and in combination with insecticides.

Pesticide screening will also continue on young apple shoots in the greenhouse. In this technique, a rubber cup is cemented around the shoot and filled with 4 ml of pesticide solution (1). Slits are made in the bark to facilitate solution uptake. After uptake, the trees are inoculated with scab spores and placed in a moist chamber for infection to occur. Thus far, greenhouse and field data are in agreement. This greenhouse technique may therefore be useful for screening chemicals prior to orchard testing.

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An 8-Year Comparison of Umbrella Kniffin and Single Curtain Training Systems on Concord Grapes

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INTRODUCTION

Grape vines are very adaptable to their environment and over the years have been grown under many types of pruning and training systems. The Umbrella Kniffin training system in its present form has been used as the standard for Concord grapes grown in Ohio for at least 15 and probably 20 years. Before this, the 4-Arm and 6-Arm Kniffin and the Keuka High Renewal systems were popular.

As production costs have increased, growers have searched for new cultural practices which would reduce overhead costs and labor, and increase yields and quality. Over the past 50 years, production has increased from 1½ tons per acre to 4 and 5 tons today (4). Better producers are growing 6 to 8 tons per acre. Many factors have been associated with this increase in production and it is difficult to separate out just one. Studies on light exposure, photosynthesis, carbohydrate metabolism, and nutrition have been very important in understanding the growth habit of grape vines (2, 5, 6, 11). Transition to the Umbrella Kniffin system, increasing trellis height, balanced pruning, chemical weed control, and proper fertilizer applications are just a few examples of methods which have been developed to interact and increase yields and quality (1, 2, 3, 7, 8, 10, 12, 13).

In the early 1960's the Geneva Double Curtain system was developed at the New York Agricultural Experiment Station (11). Components of the training system resulted in further increased productivity as well as the feasibility for mechanical harvesting from a special trellis. The GDC system, similar to the Hudson River Umbrella system, utilizes a high bi-lateral cordon. However, it incorporates the method of pruning to short 5-bud canes. This is a sharp reversal from earlier studies which showed that the 5th to 9th buds on a cane were the most fruitful (8, 9). The feasibility of mechanically harvesting grapes from a standard 2- and 3-wire trellis has also made the development and conversion of a 5-bud cane system appear practical as well as desirable. (This method has become known as the "Single Curtain" or "No Tye" training system.)

This 8-year study was conducted between 1968-1975 to compare the advantages and disadvantages of growing Concord grapes on the Single Curtain vs. the Umbrella Kniffin system.

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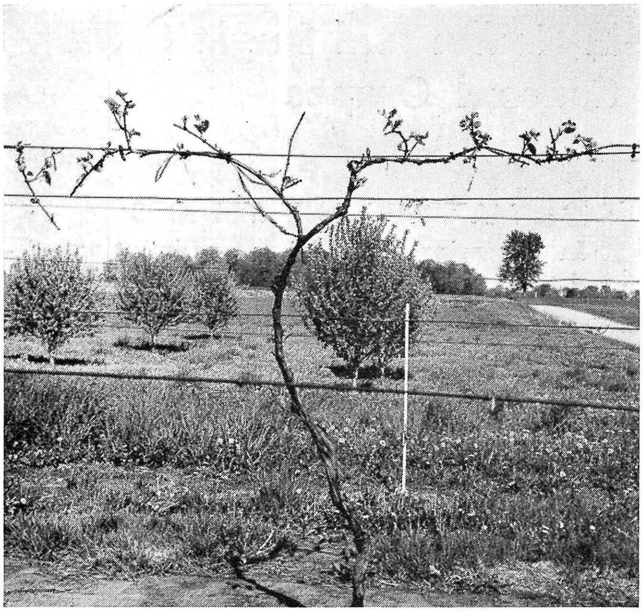
MATERIALS AND METHODS

In the spring of 1968, an experiment was designed to compare the growth and fruiting relationships between the Umbrella Kniffin and Single Curtain training systems. A ½-acre 7-year-old Concord vineyard was utilized, located at OARDC Horticulture Unit 2, Wooster. During the 7-year period (1960-67) when the vineyard was developing, it was balance pruned and trained to the Umbrella Kniffin system (Fig. 1). Pruning data in the spring of 1968 (Table 1) show that both treatments were similar in vigor and that pruning weights were the same (2.21 and 2.20 lb. per vine). The same number of buds (nodes) also were left for fruiting during the 1968 season.

A balanced pruning procedure was used as follows. Both Umbrella Kniffin and Single Curtain vines were pruned according to a 30 + 10 formula (30 buds for the first pound of wood removed plus 10 buds for each additional pound up to 4 lb.). No more than 60 buds were left regardless of the pruning weight. On the Single Curtain trained vines, two 2-year-old canes were chosen from the head of the vines to be trained as a bi-lateral cordon. These were attached to the top wire of the trellis and extended 4 feet

FIG. 1.—Eight-year-old Concord grape vines as they appeared in 1968 trained to the Umbrella Kniffin system.



in each direction (Fig. 2). One-year-old fruiting canes on the newly established cordon were pruned to 5-bud canes according to the balanced pruning formula. All others were pruned to 1-bud spurs. If a sufficient number of buds could not be retained by this procedure, then additional 1-year canes were chosen and, where possible, tied parallel to the top wire. Fruiting wood at other positions on the vines was removed. In subsequent years, fruiting canes were selected from the cordon in a manner similar to the GDC system (11, 12).

FIG. 2.—Eight-year-old Concord grape vines as they appeared in 1968 following conversion to the Single Curtain training system.

TABLE 1.—Growth, Yield, and Quality of Concord Grapes Trained to the Umbrella Kniffin and Single Curtain Systems, 1968-1975, OARDC Horticulture Unit 2, Wooster.

	Umbrella Kniffin	Single Curtain	Umbrella Kniffin	Single Curtain	Umbrella Kniffin	Single Curtain
	1968		1969		1970	
Yield (lb.)	21.40	22.80	20.20	16.50	5.95	7.48**
Cluster Wt. (lb.)	0.33	0.31	0.31	0.29	0.19	0.22
Cluster No.	97	108*	73	66	38	48**
Wt./100 Berries (g)	272	261	276	265*	241	248**
Soluble Solids (%)	13.8	13.3*	15.1	15.2	16.9	16.6
Total Acids (%)	0.68	0.68	0.57	0.59	0.44	0.42
Pruning Wt. (lb.)	2.20	2.21	1.71	1.51	1.43	1.31
Nodes Retained	42	42	36	36	34	33
Fruit Clusters/Node	2.3	2.6	2.0	1.8	1.1	1.5
Fruit Wt./Node	0.54	0.55	0.57	0.47	0.18	0.23
	1971		1972		1973	
Yield (lb.)	14.10	15.10	21.50	22.60	28.18	29.68
Cluster Wt. (lb.)	0.25	0.25	0.21	0.18*	0.22	0.20
Cluster No.	84	86	107	125**	127	150**
Wt./100 Berries (g)	289	290			280	284
Soluble Solids (%)	15.3	15.1	15.0	14.5**	13.6	13.6
Total Acids (%)	0.39	0.36	0.65	0.64	0.64	0.66
Pruning Wt. (lb.)	2.23	2.05	1.65	0.97**	3.45	1.75**
Nodes Retained	42	40*	37	32**	55	41**
Fruit Clusters/Node	2.0	2.2	2.9	3.9	2.3	3.7
Fruit Wt./Node	0.34	0.38	0.58	0.71	0.56	0.72
	1974		1975		Average	
Yield (lb.)	5.19	5.76	26.01	25.50	17.82	18.18
Cluster Wt. (lb.)	0.14	0.14	0.19	0.18	0.23	0.22
Cluster No.	37	44	134	145	87	100
Wt./100 Berries (g)	286	283			274	272
Soluble Solids (%)	14.6	15.1*	15.5	15.3	15.0	14.8
Total Acids (%)	0.93	0.94	0.63	0.66	0.62	0.62
Pruning Wt. (lb.)	3.48	1.83**	3.31	2.59**	2.43	1.81
Nodes Retained	51	37**	52	46**	44	38
Fruit Clusters/Node	0.7	1.2	2.6	3.2	2.0	2.5
Fruit Wt./Node	0.10	0.16	0.50	0.55	0.42	0.47

*Significant at the .05 level of probability.
**Significant at the .01 level of probability.

A total of 192 vines were used in the experiment. Treatments consisted of six replications of 24 vines. Each replication was divided into four 6-vine subplots. Of these six, only the center four vines were used for record purposes. Pruning was done in early spring before growth started. Standard fertilization and cultural practices for pest control were applied equally to all vines.

RESULTS AND DISCUSSION

As shown in Table 1, in 1968 yield per vine, cluster weight, weight per 100 berries, total acids, and fruit weight per node were not different between the two systems. The number of clusters harvested was greater and the soluble solids lower on the Single Curtain (SC) than the Umbrella Kniffin (UK) vines. Thus, in the transition from the UK to the SC training system, most of the production factors, especially yield, were not affected. Shoot positioning was not done the initial year. A reduction in soluble solids of 0.5% was an adverse reaction which might have been avoided by shoot positioning and better light exposure. A reduction this great was experienced in only one other year (1972).

The resulting pruning weights of 1.71 and 1.51 lb. per vine (Table 1, 1969), although reduced over the initial weights at the beginning of the experiment, were not significantly different between trellising systems. It should be noted that pruning weights for 1969 represent the growth obtained in 1968 and are the basis for the number of buds to be left for fruiting in 1969.

In 1969 all fruiting canes on the SC system were now selected from canes growing on the cordon. These canes were again pruned to 5 buds each or left as 1-bud spurs. Vines trained to the UK system remained as in the previous year.

An analysis of the results for 1969 showed that SC-trained vines produced 3.70 lb. less fruit than UK-trained vines. Berry weight was also less under the SC system. Factors which were not different included cluster number, cluster weight, soluble solids, and pruning weight, although there was some tendency for them to be smaller. Fruit clusters per node (bud) and fruit weight per node are values derived from the data and help indicate the general fruitfulness of the treatment vines in any given production year. 1969 was the only year when either of these values was higher under UK than SC-trained vines.

Pruning weights, determined in the spring of 1970 (Table 1), continued to decrease under both systems. The observation that the SC system had a lower pruning weight in either 1969 or 1970 did not prove to be justified when the data were subjected to statistical analysis. In 1970, fruit yield was reduced by a spring frost. Under this condition the SC-trained vines produced more fruit (1.53 lb. per vine) than those trained to the UK system. Cluster number, cluster weight, and berry weight all contributed toward this difference. Soluble solids were reduced 0.3%.

In the spring of 1971 (Table 1), as a result of the light crop produced the previous year, pruning weights increased to approximately the same level as when the experiment was started (2.23 and 2.05 lb.

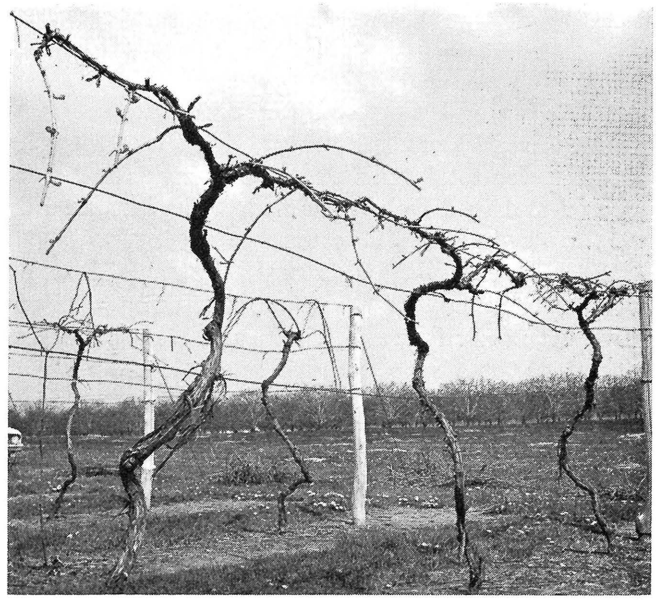


FIG. 3.—Single Curtain trained Concord grape vines as they appeared in 1974, 6 years following conversion from the Umbrella Kniffin training system.

FIG. 4.—Concord grape vines which have been trained to the Umbrella Kniffin system continuously between 1960 and 1974.

per vine). Thus, more nodes were left to fruit. However, due to adverse weather conditions, yields were again below average for both systems (14.10 and 15.10 lb. per vine). Very few differences between treatments were evident. However, there was a strong tendency for total acids and soluble solids to be decreased and fruit weight per node to be increased on vines trained to the SC system.

1972 was a very wet growing season. Pruning weights reflected the growth and fruiting relationships the previous year (1971), and were below expectations for a crop of only 14 and 15 lb. per vine (Table 1). Single Curtain vines were reduced to less than 1 lb. per vine. However, the high moisture conditions which provided excellent vegetative conditions caused pruning weights to nearly double (3.45 and 1.75 lb. per vine) the following spring (1973). Yield and total acid content between treatments in 1972 were not affected. Cluster number, fruit clusters per node, and fruit weight per node were all greater under the SC system; cluster weight and soluble solids were reduced. Berry weight was not taken.

In 1973, the highest yield produced during the 8-year period of the experiment was obtained. Even under these conditions it can be observed that the trellising treatments retained their same relative differences.

In 1974, a hailstorm very badly damaged the vines during the flowering and fruit set period. Yields were very seriously reduced under both systems, but even under such circumstances were still comparable. A higher cluster number under the SC system which consistently occurred in the experiment compensated for the reduced bud number per vine. Differences in clusters per node and fruit weight per node remained similar to previous years and were higher for the SC system. Soluble solids were statistically higher under the SC system. Figures 3 and 4 show typical vines as they had developed 6 years following the start of the experiment.

In 1975, excellent growing conditions resulted in high yields and acceptable quality in both treatments. Yields, soluble solids, cluster weight, and total acids continued to show the same trends but were not statistically significantly different between treatments.

SUMMARY AND CONCLUSIONS

Studies of the physiological principles involved in grape production have shown that maximum exposure of leaves to sunlight is very important. Shoots which will be next year's fruiting canes are more productive if their leaves are fully exposed to light (6, 11). Much of the grower preference for the Umbrella Kniffin system has been due to this proven yield-quality relationship. Training systems which are able to improve production and/or quality over and above this owe much of their success to the application of this important principle. This is the case with the Geneva Double Curtain system.

The Single Curtain system used here is similar in design to the Geneva Double Curtain. The major difference is that only half of the trellis area was available for light exposure and shoot positioning. For vines which were only moderately vigorous such as those at the start of the present experiment, the conventional UK trellis should have provided adequate exposure to handle the foliage produced. By contrast, vines with pruning weights above 3.5-4.0 lb. per vine should benefit by conversion to the GDC or new SC system.

During the 8-year period of the experiment, some typical variations occurred in weather conditions which might be expected in any such time span here in Ohio. This experiment provides valuable data on just how these two training systems might be expected to perform under the various growing conditions. With this in mind, the following conclusions are made:

- Yields, although variable from year to year, were very similar when all 8 years were averaged (Table 1). Other than in 1970 when a spring frost severely reduced yields, no definite yield advantages were observed for the SC system.
- Training system did not affect the size of clusters produced.
- The SC training system produced a greater number of clusters per bud (node). If this had not been true, the UK system would have produced significantly more fruit most years, since both systems were strictly pruned to a 30 + 10 balanced pruning formula.
- Berry weight (size) was not consistently affected by either training system.
- Soluble solids contents of berries from the SC system were seldom higher but usually the same or lower than berries on the UK system. A reduction in soluble solids would be a typical reaction in any fruit crop if the number of leaves per fruit were reduced. Such a relationship is indicated by the lower pruning weights under the SC vines, although no measurements were taken.
- Total acid contents were not generally affected by training system.
- Pruning weights were materially reduced under the SC system. In fact, this appears to be the

major concern of the system. Care must be taken to include single bud spurs in the total bud count in order to maintain vigor.

- The SC vines were consistently more fruitful in terms of clusters of fruit or fruit weight per node retained. This indicated that a greater physiological stress may have been present on the vine which generally resulted in lower soluble solids. Exposure to a greater amount of sunlight by shoot positioning, which was carried out from 1969-1975, should have helped overcome this condition. It could be rationalized that this was the case since a similar state of maturity was maintained under a less vigorous condition (lower pruning weight).
- As previously noted in the literature (8, 9), the 4th to 9th buds have been shown to be the most fruitful on Kniffin-trained vines. The ability of a Concord vine to produce satisfactorily on a 5-bud system indicates that exposure of basal buds to light is an important cultural consideration.
- It was shown that conversion from the UK to the SC system can be accomplished without sacrificing yield.

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Center Headquarters, Wooster, Wayne County: 1953 acres

Eastern Ohio Resource Development Center, Caldwell, Noble County: 2053 acres

Green Springs Crops Research Unit, Green Springs, Sandusky County: 26 acres

Jackson Branch, Jackson, Jackson County: 344 acres

Mahoning County Farm, Canfield: 275 acres

Muck Crops Branch, Willard, Huron County: 15 acres

North Appalachian Experimental Watershed, Coshocton, Coshocton County: 1047 acres (Cooperative with Agricultural Research Service, U. S. Dept. of Agriculture)

North Central Branch, Vickery, Erie County: 335 acres

Northwestern Branch, Hoytville, Wood County: 247 acres

Pomerene Forest Laboratory, Coshocton County: 227 acres

Southern Branch, Ripley, Brown County: 275 acres

Western Branch, South Charleston, Clark County: 428 acres